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Office of the Secretary
Federal Communications Commission
1919 M Street, N.W., Room 222
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RE: **Comments of the students of the Spring 1996 seminar on Telecommunications Modeling and Policy Analysis at the Massachusetts Institute of Technology on the petition filed by the America's Carrier's Telecommunication's Association (ACTA) requesting the ban of Internet telephony software (RM-8775).**

The attached seminar on Telecommunications Modeling and Policy Analysis comments regarding RM-8775 are based on the results of the group's engineering cost model of Internet telephony, and the group's analysis of the current state of the Internet telephony technology. The comments are intended to provide the Commission essential and supplemental information about this new and emerging technology. Hence, the purpose is to supply a more complete record for an informed decision-making process regarding the ACTA petition.

Accordingly, we urge the Commission to accept the attached comments and supporting rationale that explain Internet telephony technology and the accompanying business and policy environments.

The conclusions expressed herein are not those of the Massachusetts Institute of Technology or the Research Program on Communications Policy. The views expressed are those of the students of the Spring 1996 seminar on Telecommunications Modeling and Policy Analysis.

Please contact Andrew Sears at (617) 253-4138 if you require additional information concerning any aspects of these comments.

Very truly yours,

Don O'Sullivan

cc: Wanda Harris, Common Carrier Bureau -- with attachments
International Transcription Service, Inc. -- with attachments

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Before the
FEDERAL COMMUNICATIONS COMMISSION
Washington, D.C. 20554

In the Matter of	)	
The Provision of Interstate and International Interexchange Telecommunications Service via the "Internet" by Non-Tariffed, Uncertified Entities	)	RM-8775

Comments of:

Students of the Telecommunications
Modeling and Policy Analysis Seminar
Massachusetts Institute of Technology
77 Massachusetts Avenue
Room E40-242
Cambridge, MA 02139

Respectfully submitted,

Students of the MIT Telecommunications
Modeling and Policy Analysis Seminar

Executive Summary

A qualitative analysis of the market of Internet access as well as a quantitative cost model of Internet telephony are the basis of this comment. Within this model, three scenarios were studied:

- Internet Access Providers (IAPs), enabling Internet telephony between computers,
- Gateway, providing Internet telephony between telephones,
- Regulation effects, if IAPs are required to pay the local access subsidy.

It was found that the majority of the costs seen by the IAP result from internal costs rather than the price of leasing local lines or connection to the Internet. It is argued that this situation provides a high incentive for competition because IAPs have control over their costs. That would not be the case if IAPs were regulated.

From this analysis, the following conclusions can be reached:

- Due to lack of capacity and poor quality of service currently available, Internet telephony cannot be considered a serious threat to ACTA members at this time.
- Internet telephony can potentially be priced competitively with current PSTN long-distance services, even with the addition of a local access subsidy. Indeed, the majority of the savings brought by Internet telephony comes from sources other than the mere exemption of the local access subsidy.

- However, if this fee is added, it will account for the largest component of IAP's cost. Hence, the LECs would have such a large competitive advantage that they would eventually become a monopoly for Internet access over PSTN lines. Hence, regulation of IAPs would harm competition among Internet Access Providers.

Consequently, the following recommendations can be formulated:

- The FCC should refrain from regulating Internet telephony at this time in order to allow this new technology to mature to a level where it can compete effectively with current PSTN long distance services.
- This issue should be revisited in the future, taking into account how technological progress has improved the quality and availability of Internet telephony service and the resulting impacts on the market of ACTA members.
- Future regulation, if deemed necessary, should be structured in a way that avoids granting a competitive advantage to LECs in providing Internet access.

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Introduction

These comments are submitted by the students in the Spring 1996 seminar on Telecommunications Modeling and Policy Analysis at the Massachusetts Institute of Technology. This seminar is composed of twelve graduate students in the Technology and Policy Program. The students bring to the seminar a diverse set of skills and experiences, but a common interest in telecommunications policy and its development. As a final project, the students have chosen to address the petition filed by the America's Carriers Telecommunication Association (ACTA) concerning Internet Telephony.

This filing presents the group's recommendations to the FCC regarding ACTA's petition. These recommendations are based on both the results of the group's engineering cost model of Internet telephony, and on the group's analysis of the current state of Internet telephony technology. The purpose of the following analysis is to aid the FCC in making an informed decision on the ACTA petition.

First, the paper provides a brief overview of the architecture of Internet telephony compared to that of the current public switched telephone network. The basic structure of the cost model is then described, followed by the results and an analysis of the model for three different scenarios. Finally, the group's conclusions and policy recommendations are presented. More detailed information about the cost model and additional material can be found in the Appendices.

Comparison of Telephone Network Architectures:

Currently, long distance phone calls are made by connecting to a long distance carrier's point-of-presence (POP) through a local central office. The long distance carrier's POP serves as a local interconnection point to its long distance network, which is made up of 5 levels of hierarchical switching offices, in a tree-like structure. There are approximately a dozen "regional class 1" (the highest level) switching offices that serve the U.S. and Canada. A simple diagram of the Public Switched Telephone Network (PSTN) is shown in Figure 1.

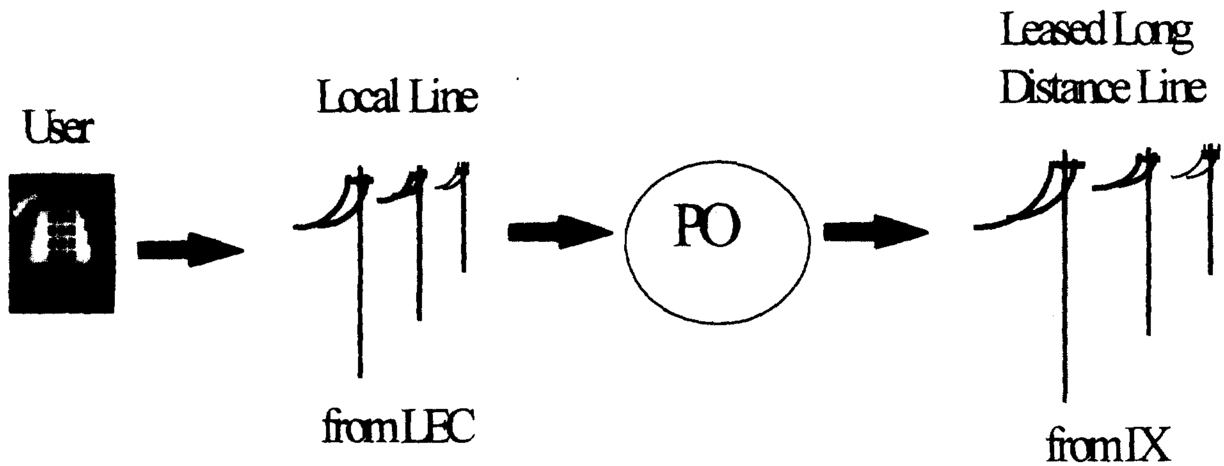

Figure 1. Calls through the PSTN

Long distance phone calls using IT are made by connecting through the central office to the Internet Access Provider (IAP) or Gateway (depending on whether the call is being made through a computer or a standard phone). This IAP/Gateway can be considered an Internet Point-of-Presence (IPOP), analogous to the long distance carrier's POP. Similarly, the IPOP serves as a connection point to the Internet, through Internet Service Providers (ISPs) that serve multiple IAPs. The ISPs themselves are connected through Network Access Points (NAPs), five of which serve the United States. Figure 2 shows a simple diagram of the Internet telephony architecture.

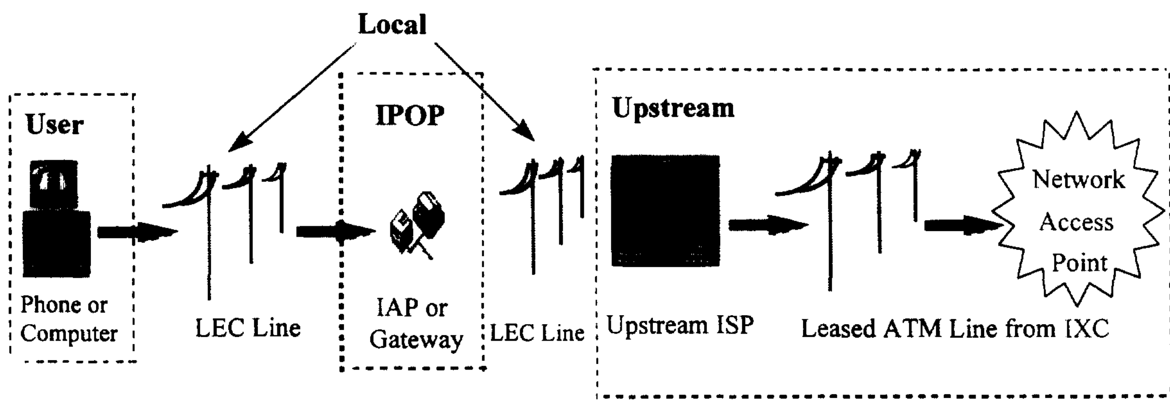

Figure 2. Calls through Internet Telephony

Note: for background on Internet telephony technology, see Appendix B

Cost Model for Internet Telephony

The purpose of this section is to lay the general framework for a cost model of Internet telephony, which can be contrasted with the costs of providing a telephone call on the Public Switched Telephone Network (PSTN). The model and a detailed description of its parts can be found in Appendices C through G. Since Internet telephony (IT) is a relatively new technology, there are no existing cost analyses. The intention is not to provide an exhaustive cost comparison between PSTN and Internet telephony, but simply to draw distinctions between the various cost components to contrast the cost of delivering a call through the Internet and the PSTN. The cost of the PSTN has already been the subject of many studies, such as "Incremental Costs of Telephone Access and Local Use" by the RAND Corporation. This paper will focus on the Internet model for delivering long distance phone calls rather than modeling both networks.

All long distance calls include costs for the local loop, a point of presence (POP), and an upstream or "long distance" portion. To better understand the costs of delivering Internet telephony, it is useful to contrast the differences between calls placed through the PSTN and the Internet. Figure 3 shows the parallel cost components of Internet telephony and PSTN.

PSTN

Local Loop + POP + LD = PSTN Cost

Internet

Local Loop + IPOP + Upstream = Internet Cost

Figure 3. PSTN and Internet telephony costs

While the models of the two networks appear quite similar, there are differences in the costs of each of the components, in particular:

1. **Local Loop Costs (C_{local}):** Local loop costs are similar because they use essentially the same lines. The only difference between these costs is in the method of interconnection between the local loop and the POP. For the PSTN, the long distance carrier's POP is collocated in the local telephone company's facility. This allows users to make long distance calls with one number dialing. In contrast, users of Internet telephony must first call the local IPOP, which will then route the call to the destination. For the purpose of this model, local loop costs for Internet telephony include the cost of the incoming lines (through which they are connected to their users) and the costs of the leased lines that connect the IPOP to its upstream Internet Service Provider. See appendix C for details on the IT local loop cost model.
2. **POP Costs (C_{IPOP}):** The POP in the PSTN model consists of the LD carrier's interconnection equipment which is collocated in a LEC facility. For Internet telephony, the IPOP is an Internet Access Provider. For the model, this includes all operating costs of an IAP except the cost of leased lines and interconnection with an upstream Internet Service Provider. See appendix D for details on the IT IAP/gateway (IPOP) cost model.
3. **Upstream/LD Costs ($C_{upstream}$):** The long distance component of the PSTN consists of circuit switched lines. This includes the cost of the physical lines and the cost of the digital circuit switches. The upstream component for the Internet telephony model consists of Internet Service Providers (ISPs), which are connected by Internet routers and ATM switches. . See appendix E for details on the IT upstream cost model.

In summary, the costs considered for Internet telephony can be loosely described by the following formula:

$$C_{total} = C_{local} + C_{IPOP} + C_{upstream}$$

The following three sections present different scenarios regarding how IT service can be provided and regulated, and how costs may be affected. Specifically, the three scenarios addressed are:

1. Computer to computer communication - the current operating architecture for IT.
2. Phone to phone communication using IT - a future model of an IT architecture.
3. Regulated IT - how the addition of a subsidy into IT access affects costs seen by the IAP.

IAP Price Model: The Costs Seen By Current IAPs

Explanation and Significance of the Computer to Computer Model

The computer to computer cost model does not attempt to measure the true end-to-end cost of Internet telephony, but instead uses current prices seen by the IAP within a cost model framework. Further, the cost model provides insight into why IAP's are able to provide Internet telephony at their current prices. Demonstrating the cost from an IAP's perspective will help explain the incentive for an IAP to enter this market, an important consideration when measuring the potential growth and competition. In addition, the cost model illustrates where various costs are realized for an IAP delivering Internet telephony, which may be useful in considering the possible effects of various regulations. Another purpose of the model will be to consider the accusation that the cost savings of Internet telephony comes entirely from regulatory savings, by detailing where savings are actually realized.

Results

The key result, when comparing with PSTN, is the price per minute, which is approximately $0.015/min. This only includes the IAP cost for one side of the call, and since each call involves two IAPs the total cost is near $0.03/min. It is important to note, however, that this cost is split between two users, so that the actual price seen by each user is closer to $0.015/min. These prices, and all prices that follow, should be taken as approximations based on a specific set of input assumptions. Justification for these assumptions and a sensitivity analysis can be found in Appendices F and G. The per-minute price actually ranges from about $0.01 to about $0.03 (instead of the exact $0.015 stated) over a reasonable set of inputs values, but the analysis that follows is valid over this range.

Figure 4 below shows the various cost percentages of the three components of the model. One of the key results demonstrated by the first chart is that the IPOP costs constitute the largest portion of the total costs of providing Internet access. The second chart below compares the cost of a call through the Internet with the average price through the PSTN, based on the $0.22/min. claimed by ACTA (DLD Digest, 3/5/96), and demonstrates where savings are realized.

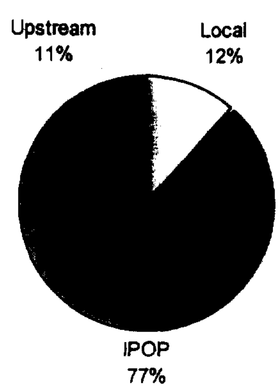

Figure 4. Cost Percentages of Model Components in cents per minute for IAP Model

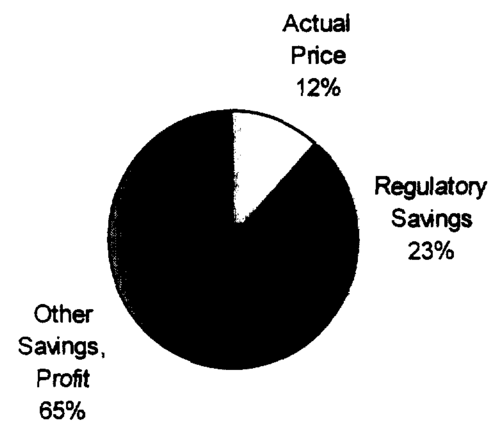

Figure 5. Savings from Regulation & Other Sources in cents per minute for IAP model

Conclusions from Results

1. **The cost structure for IAPs promotes competition.** This is because the majority of cost seen by the IAPs are internal costs that they control rather than prices for local lines and Internet access. This allows IAPs to differentiate their price by reducing their internal costs. If a local access fee were charged to the IAPs then the majority of their costs would not be in their control, making it more difficult to differentiate themselves by reducing internal costs.
2. **Price savings do not come entirely from the bypass of regulation.** It has been argued that the only reason why IAPs are able to price Internet telephony so low is because they are not regulated. The results of our model demonstrate that IAPs are able to realize some of their savings by avoiding the local access fee, but the majority of savings from Internet telephony comes from other sources.

Other Sources of Savings

There are three ways that Internet telephony produces savings to the end user. The first source of savings comes from the customer premise and the upstream portion of our model. The first source of savings comes from an increase in intelligence in the customer premises equipment because a computer is used rather than a telephone. Peter Huber argues in *The Geodesic Network* that there are incentives for the intelligence of the network to move from the center to the periphery.[1] Internet telephony is an example of this, as some of the intelligence of the network lies in the computer at the customer premises. As a result, Internet telephony may allow the user to see a upstream price savings as high as of a factor of 100.[2]

The second area where savings is realized comes from the efficiencies of packet switching. While these savings are greatest for bursty data, they are still significant for voice

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[1] Huber, Peter. *The Geodesic Network II.* The Geodesic Company, 1992.

[2] The computer does this through the compression of the voice signal and the conversion of that single into a packet formatted for the Internet. The compression introduces efficiency by providing bandwidth savings, and the Internet format allows the IAP to bypass the intelligence in the LD network by going through the Internet. In the existing telecommunications infrastructure, compression is not used because it costs more to compress than the savings gained, except for international calls. However, this is not true with Internet telephony, since the user already has a computer, the marginal cost of the compression is zero. This allows the user to realize a true cost savings using compression. Current Internet telephony software provides compression ranging from a factor 2 to over 50, but the most commonly used standard is GSM compression which provides a compression ratio of 4.5:1.

The second area that savings are realized comes from the efficiencies of packet switching. While these savings are greatest for bursty data, they are still significant for voice signals. Through silence suppression and bandwidth sharing it is possible to gain an efficiency of another factor of two.

The third area in which savings can be realized is through the leasing of bulk lines that are used for the high capacity lines for the Internet. Our model shows that the average IAP connects to an ISP using T1 lines, and the ISPs connect together using T3 lines. This method of aggregating traffic happens to be a very efficient way to utilize the existing network. We assume that T1 lines produce a price savings of a factor of 5 over T0 lines, and T3 lines produce a price savings over T1 lines, giving a savings of a factor of 20 over T0 lines. The reason for this price difference is not from regulation, but is comes from the fact that competition is much more intense for high capacity lines.

A full discussion of this savings as well as references for these results can be found in "An Analysis of the ACTA Filing to Ban Internet Telephony" signals. Through silence suppression and bandwidth sharing it is possible to gain an efficiency of another factor of two.[3]

The third area in which savings can be realized is through the leasing of bulk lines that are used for the high capacity lines of the Internet. Our model shows that the average IAP connects to an ISP using T1 lines, and the ISPs connect together using T3 lines. This method of aggregating traffic happens to be a very efficient way to utilize the existing network. We assume that T1 lines produce a price savings of a factor of 5 over T0 lines, and T3 lines produce a price savings of 4 over T1 lines, giving a total savings of a factor of 20 over T0 lines (dollars per amount of bandwidth). The reason for this price difference is not from regulation, but partially from the fact that competition is much more intense for high capacity lines.[4]

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[3] Sears, A., Mutooni, P., Li, B., "A Business and Policy Analysis of the ACTA Petition to Ban Internet Telephony"
[4] Sears, Mutooni, Li

Gateway Price Model: Costs Seen by Gateway Provider

Explanation and Key Assumptions for the Phone to Phone Model

The purpose of the phone to phone model is to consider what the price might be in the future for phone-to-phone calls through the Internet. The phone to phone model is similar to the above model except that the IAP provides a "gateway" which allows users to make Internet telephony calls with regular telephones (instead of requiring users to have a computer). As in the previous section, this model considers costs seen by an IAP to determine whether it is possible to provide this type of service. This is an important consideration because it will determine if there are incentives for new entrants to provide phone-to-phone Internet telephony. It should be noted again that while specific prices are quite dependent on some key assumptions (in particular, number of subscribers per line and average monthly usage), the analysis remains valid for the range of reasonable input assumptions. An explanation and justification of these assumptions can be found in Appendices F and G.

Results

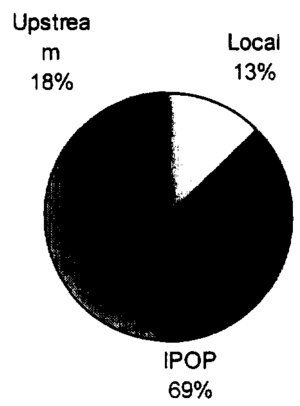

Figure 7. Cost Percentages of Model Components in cents per minute for Gateway Model

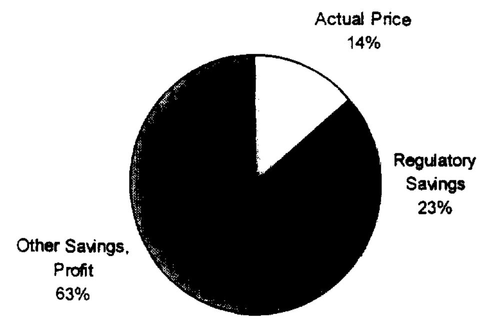

Figure 6. Savings from Regulation & Other Sources in cents per minute for Gateway Model

An important result of this model is that the price of phone to phone Internet telephony provided by an IAP is similar to the price of Internet access. This is not to say that long distance Internet phone service will be priced the same as Internet access, but that it may be possible to price near the same levels and still realize a profit. It is impossible to know exactly how this service will be priced because it has yet to be provided on a commercial basis. International Discount Telecommunications has announced a computer to phone service (that would thus incorporate half of the above costs) at an announced price of 10 cents per minute. Our model indicates that this pricing is not unreasonable, and may in fact allow for a significant profit margin.

Regulatory Model: Modeling Regulatory Effects

Description and Purpose of Model

The purpose of this section is to consider how regulation might affect the price of Internet telephony and Internet access in general. The model focuses on the key issue under consideration, which is whether IAPs should be required to pay the local access subsidy to the LECs. While adding the local access fee to the price of Internet access appears trivial, several important effects result from this model. The most important effect is how the subsidy changes the cost percentages of the local, IPOP, and upstream components seen by a provider. This is an important consideration because how these cost are allocated will influence who can effectively compete in the market.

Results

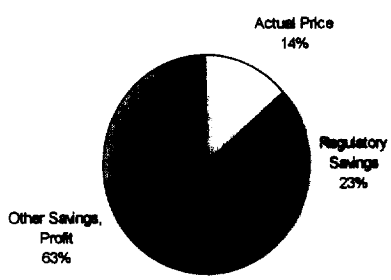

Figure 88. Cost Percentages of Model Components in cents per minute for Regulatory Model

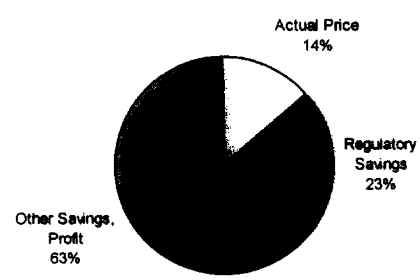

Figure 9. Savings from Regulation & Other Sources in cents per minute for Regulatory Model

The above results show that the local access fee would become the largest single portion of costs to an IAP. While this eliminates the regulatory savings from previous sections, Internet telephony can still provide considerable savings when compared to the average cost of a long distance call.

Conclusions from Results: Effects on Competition in the IAP Market

The IAP Price model demonstrates that the majority of the cost of providing Internet access lie in the internal operations of the IPOP. This has important repercussions on the issue of competition, which can be illustrated by considering how the IAP's costs might change if the Internet access provider were a LEC or an Inter-exchange Carrier (IXC). The IXC's could leverage their existing infrastructure, which would allow them lower their upstream component costs. Because the upstream component is only a small portion of the total costs seen by an IAP, this would not be a large advantage, and traditional IAPs may still be able to compete with these IXC's acting as IAP's. Similarly, in the current market situation, LECs would not have a significant competitive advantage in providing Internet access because the local component is a small percentage of total cost.

However, this situation would change if IAP's were required to pay a local subsidy to the LEC for providing Internet access. As shown in the above charts, a local access becomes a very significant portion of total costs seen by an IAP. Since LEC do not need to pay a local access fee to themselves, they would be able to provide Internet access without this major cost component. On the other hand, IXC's and traditional IAPs required to pay this access fee would find themselves at a considerable disadvantage in providing Internet access. In fact, a local access fee of 2.5 cents per minute means a fee of $1.50 an hour, which is more than many IAPs are currently charging for Internet access. This means that even if non-LEC IAPs have no costs other than their local component, the still would not be able to compete with LECs offering Internet access. The result would be an extension of the LEC's monopoly to include Internet access.5

[5] This conclusion is validated by the situation in countries in Europe and other countries which require a per minute fee for local calls. This presents the opportunity for the PTT to cross-subsidize Internet access, and the result has been a monopolization of Internet access by the PTT.

Conclusions and Recommendations

These comments consider the issue of regulating Internet telephony as requested by ACTA members. In so doing, important information has emerged in three areas relevant to the decision-making process. They are: the threat of Internet telephony to ACTA members, the potential competitiveness of Internet telephony vs. PSTN long distance, and the possible consequences of regulating Internet telephony. Summaries of each of these discussions are given below. Conclusions are identified after each section. Finally, policy recommendations are formulated based on the conclusions from these three areas.

Threat of Internet Telephony to ACTA CARRIERS

At present, only individuals with access to a personal computer with the necessary peripherals (full duplex sound card, microphone, and speakers) are able to make long distance phone calls via the Internet. The gateways necessary for phone to phone telephony are not currently capable of handling more than one call at a time. Gateways to handle multiple calls are in development, but it will be several years before they are ready for commercial use. Thus, Internet telephony, in its present level of development, can handle only an extremely limited capacity of calls.

While reserving a fixed amount of bandwidth in a PSTN call may be wasteful, it does serve as an easy way to guarantee a certain level of quality for the call. Unfortunately, the Internet is currently based on a "best effort" model of service, in which packets can be dropped (with the expectation that they will be re-sent) if the traffic in a part of the network is too high. While this model may work well enough for non-real-time applications such as e-mail, it can result in an unacceptably poor level of quality for real-time applications such as telephony. Network protocols which can provide some quality of service guarantees (such as RSVP) are neither widely supported nor deployed and may not be for some time.

Future improvements in these areas hold the promise of improving the quality and availability of real-time applications via the Internet. These technological advances, however, are likely several years away. Based on these arguments, we draw the following conclusion:

- **Due to the lack of capacity and poor quality of service currently available, Internet telephony cannot be considered a serious threat to ACTA members at this time.**

Cost Competitiveness of Internet Telephony vs PSTN Long Distance

In an effort to quantify the cost structure of providing Internet telephony, a model was developed to determine the approximate costs incurred by an Internet Access Provider (IAP). In cases where cost data was not available, the model uses the conservative assumption that costs of the service is equal to the price charged for the service. The model showed that the peak cost of a computer to computer Internet telephony call is approximately $0.03 per minute neglecting any additional charges to subsidize local access. Utilizing an Internet telephony gateway to provide a phone to phone connection is shown to increase per minute costs only negligibly.

The model also shows that adding a local access subsidy to the cost of long distance calls made via the Internet increases the costs of that call to approximately $0.08 per minute for either computer to computer or phone to phone connections. Adding a profit margin to the $0.08 per minute cost and comparing the resulting price to the current $0.22 per minute price of PSTN long distance service as cited by the ACTA carriers ("DLD Digest," March 5, 1996) would still yield a competitive price.

Based on these arguments, we make the following conclusion:

- **Internet telephony can potentially be priced competitively with that of current PSTN long-distance services even with the addition of local access subsidy.**

Consequences of Regulating Internet Telephony

The cost model has shown that the majority of the cost of providing Internet telephony comes from the internal operations costs of the IPOP. Internal operating costs represent ~77% and ~70% of the IAP's total costs for the computer to computer and phone to phone connections respectively. Local and upstream costs are a minor portion of the total. Thus LECs, which see lower local costs and IXCs, which see lower upstream costs do not currently have a significant advantage over traditional IAPs in the market of providing Internet access. IAPs have the ability and incentive to lower their price by reducing internal costs.

The model also shows that adding a local access subsidy to the cost of long distance calls made via the Internet decreases the portion representing IAP's internal operating costs